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ML and VS partnership yields spacecraft radiator panel

by Timothy Anderl, Materials and Manufacturing Directorate

WRIGHT-PATTERSON AFB, Ohio —A unique partnership between Air Force Research Laboratory Materials and Manufacturing and Space Vehicles Directorates, the Navy, NASA and industry partners yielded a revolutionary carbon-carbon radiator panel that could increase the service lives of satellites, while reducing the cost of putting them in orbit.

NASA's Earth Observing 1 (EO-1) satellite, which carries the radiator panel, was launched from Vandenberg AFB, Calif., November 21, 2000. The satellite is the first of three New Millennium Program Earth-Orbiting missions that demonstrates new instruments and spacecraft systems.

In 1994, at a conference in Florida, a conversation birthed a partnership that would make the development of the carbon-carbon radiator panel possible.

"The partnership wondered why nobody used the material," said Elizabeth Shinn, an engineer in the Nonmetallic Materials Division of Air Force Research Laboratory's (AFRL) Materials and Manufacturing Directorate.

Knowing that future spacecraft will require smaller and more closely packed electronic components, and that radiator panels will need to be lighter and conduct more thermal heat, Shinn and her peers organized the Carbon-Carbon Space Radiator Partnership. Led by Shinn and NASA Langley's Howard Maahs, the partnership was dedicated to promoting the use of carbon-carbon, a light and highly conductive composite material in spacecraft.

"We determined that it was because no one really knew much about it," Shinn said. "So we started working together to get carbon-carbon used as a material for space systems. When the flight opportunity came along, we tailored our efforts to it."

"Everyone involved brought something to the table — be it man hours, financial support or testing capabilities — and we shared the data and the decisions. The partnership was based on this mutual interest in the material and operated without any formal agreement, aside from handshakes."

Dan Butler, Thermal Technology Development Group Leader at NASA Goddard, Greenbelt, Md., agreed. "We have used simi-

lar agreements in the past and found that a handshake agreement is sometimes better than what you can get on paper.

"In this case, when we first got together to develop a formal agreement between all the separate agencies we realized the administrative hurdles it would require," Butler said. "So we decided to pursue collaboration without the 'formalities' and are pleased everyone came through. The group had a good rapport and were very appreciative of what others brought to the table."

Experts in various areas of materials research and testing, the team discussed trends in satellites and their radiator panels.

Satellites in orbit carry electronic components that generate heat while they perform their jobs. They also absorb solar radiation. Radiator panels, which are a structural element of the satellite, prevent damage to these heat sensitive components by conducting and radiating heat away from them.

"The higher the temperature the more advantageous carbon-carbon is because it does not lose its ability to conduct thermal energy like most other materials do," Shinn said. "It makes sense because carbon-carbon is made at a high tem-



UNIQUE PARTNERSHIP — The Carbon-Carbon Space Radiator Partnership, a team of scientists and engineers from AFRL, the Navy, NASA and industry, display their flight-ready panel.

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perature and heat treated to even higher temperatures.”

Knowing this, the partnership took several steps to propose a space flight for the radiator panel. Wallace Vaughn, a materials research engineer at NASA Langley Research Center, Hampton, Va., and Bob Acree, an engineer from AFRL’s Space Vehicles Directorate at Kirtland AFB, NM, wrote the original proposal to the New Millenium Program suggesting use of a carbon-carbon facesheet radiator on the New Millenium Program’s EO-1 spacecraft.

The radiator seemed like a natural match for the satellite. NASA had designed the New Millennium Program to help identify, develop and test new more cost effective spacecraft technologies. The program involves launching small satellites, about one-third the size of typical operational satellites, which test materials and components that may be used in future full-sized satellites,

First, the Navy built eight carbon-carbon facesheets for destructive and nondestructive testing.

Lockheed Martin built three identical radiators – one for use on the satellite, another as a back up, and a final panel for destructive testing – that had an aluminum honeycomb core with a carbon-carbon facesheet on both sides. They also responded to any system level concerns and issues raised by the panel integrator and satellite builder, Swales.

One of the first issues was to prove or qualify the panel for space. When the panels were built, NASA Goddard did thermal vacuum testing to simulate the space environment. They also did vibration testing to simulate launch and flight conditions, and thermal testing to simulate extremes that the panel would encounter.

NASA Langley did the mechanical characterization of the facesheet materials and coordinated the conductivity testing performed by NASA Goddard and Lockheed. Lockheed Martin performed the mechanical evaluations of the “sandwich” (the carbon-carbon facesheets with an aluminum honeycomb) structure. The Air Force and NASA contributed funding and contract vehicles that were imperative to getting the work accomplished.

When the panel was completed, the partnership was the first group to deliver their experiment to EO-1 integrators.

“The partnership really worked because we were driven to make sure the radiator panel was included in the EO-1 spacecraft,” said Dr. Suraj Rawal, manager of Advanced Structures and Materials at Lockheed Martin Space Systems. “There was professional dedication for the success of the EO-1 radiator, and we had to remain adaptable to meet any changes in schedule, requirements, etc. We all had a deep sense of personal and professional commitment because this was our joint project never to be abandoned.”

There were a few detours on the road to integrating the panel in the EO-1. While Swales was integrating the EO-1 spacecraft with the carbon-carbon panel, the panel was damaged.

“One of the complaints that has always been prevalent about carbon-carbon is its brittleness” Shinn said. “But Swales was able to repair the panel using an epoxy and showed that one can use this as an everyday engineered material. It is not so fragile that you can’t fix or work with it – you can repair it.

In the past, aluminum has been used in satellite radiator panels because of its conductivity, and structural and physical properties. However, there are lighter weight and better performing material alternatives, such as carbon carbon. In order for aluminum panels to work, they have to be thicker near high heat load zones. In some circumstances, using a lighter panel could provide weight savings for additional payloads. @